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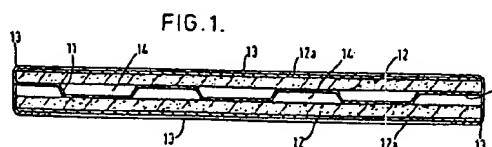
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54 Fire-resistant door leaf.

57 A fire-resistant door leaf for use in an "A" Class marine bulkhead door assembly comprises a core sandwiched between two panels. The core is a corrugated steel membrane (11) whilst each of the two panels is a pre-formed rigid board (12) of fibre-reinforced cement. An air gap (14) is created between the panels (12) by the corrugated core (11). A U-section capping channel (13) extends around the periphery of the door leaf and is corner-mitred and welded into a rigid framework enclosing the panels (12) and corrugated core membrane (11).

The membrane (11) is spot-welded to the top and bottom rails of the capping channel (13), and the panels (12) are glued to respective corrugations of the membrane (11).

The door leaf thereby derives its main flexural rigidity from its core region, and its main heat-resistance from its outer panels.



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FIRE-RESISTANT DOOR LEAFFIELD OF THE INVENTION

5 The invention relates to fire-resistant door assemblies and in particular to door assemblies for use in closing openings in marine bulkheads. The construction and properties of such door assemblies is governed, in the case of United Kingdom registered ships, by Merchant Shipping Regulations issued by the United Kingdom Department of Trade.

10 The UK Department of Trade Regulations conform to an Internationally accepted set of Regulations in compliance with the International Convention for the Safety of Life at Sea (SOLAS Regulations), which are in turn interpreted by an Exchange of Notes Treaty signed by the governments of the countries concerned. Thus the  
15 design and construction of what are called, in the United Kingdom, "A" Class Marine Fire Doors must conform to an essentially Internationally accepted set of Regulations.

20 A door which is intended to be used to close-off openings in "A" Class Divisions is, in general, required to be subjected to a standard fire test. The door leaf and frame are installed in a steel bulkhead, insulated on its unexposed side with material of the same standard as that which the door is intended to achieve, and when

the division is exposed to a standard fire test the door must prevent the passage of smoke and flame to the end of the test; and the average temperature on the unexposed side of the division must not increase by more than a stated amount above the initial temperature, nor must the temperature at any point rise more than a similarly stated amount above the initial temperature within the test time.

For a 'so-called "A60" door, the test time is sixty minutes. For an "A30" standard door, the test time is thirty minutes. Currently, the temperature limits are 139 degrees centigrade average temperature rise above the initial temperature, and 180 degrees centigrade maximum rise above the initial temperature at any one point, within the applicable test times.

#### REVIEW OF THE PRIOR ART

The Regulations applicable to this special field of fire-resistant marine bulkheads specify that the door leaf shall comprise, inter alia, a steel membrane. In all relevant prior art currently known to the applicant, this requirement for a steel membrane has always been interpreted to mean an external steel panel.

In conventional marine bulkhead "A" Class fire doors, therefore, the door leaf comprises a heat-resistant core of, for example, Vermiculite, sandwiched between two steel panels. The core is fairly thick in comparison with the two panels. If a fire occurs on one side of the door, the Vermiculite core cuts down the rate of heat transfer from one steel panel to the other. The core, relatively easily damaged, is also protected in use by the stronger and more resilient outer panels, which can be painted and to which door furniture such as locks, latches and hinges can be secured.

Thus the conventional "A" Class door leaf derives its main flexural stiffness from its outer panel

"membranes", and its main heat resistance from its core region.

SUMMARY OF THE INVENTION

5 A fire-resistant door leaf embodying the invention also  
comprises a core sandwiched between two panels, but the  
core in this case is the main leaf-stiffening membrane,  
and the panels between which it is sandwiched constitute the main heat-resisting medium. Thus the core  
10 has a much higher flexural rigidity than either of the  
outer panels, whilst the panels each have a much lower  
thermal conductivity than the core. Also, the core  
membrane will be much thinner than either of the outer  
panels.

15 Such a door leaf, deriving its main flexural stiffness  
from its core region and its main heat resistance from  
its outer panels, is thus a complete reversal of conventional thinking in the field of fire-resistant  
marine doors.

20 Many advantages flow from such a construction. Because  
only one of the relatively heavy membranes is used,  
rather than two, the door leaf will be less heavy than  
a similarly-sized and similarly-rated conventional leaf.  
It will also be less expensive, and the money saved can  
be used to furnish the door leaf with, for example,  
25 stainless steel fittings and/or peripheral capping  
channels which are less prone to rust and are thus  
particularly advantageous in a marine environment. The  
heat-resistant outer panels can be selected from modern  
materials such as fibre-reinforced cement, although  
30 more conventional materials might equally well be used  
in some circumstances. Such panels can be self-  
coloured without necessarily needing painting, thus  
saving future maintenance costs. Other advantages will  
become apparent to those skilled in this specialist  
35 field.

5 The core membrane may advantageously be corrugated, with corrugations running from side to side or from top to bottom of the door leaf. This will increase the flexural rigidity of the door whilst enabling a relatively thin and lightweight membrane to be used.

10 An air gap may deliberately be created between the panels of heat-resistant material, so that the panels are separated by the air gap as well as by the core membrane, and the air gap forms part of the core region of the door leaf. Although the core membrane will be much thinner than either of the outer panels in normal cases, the thickness of the core region (including the air gap) need not necessarily be less than a panel thickness, and may advantageously be at least equal to  
15 a panel thickness. Because air is a good heat insulator, the presence of an air gap at the core region increases the fire-resistant properties of the door leaf yet farther and gives added protection to the relatively high-thermal-conductivity core membrane.

20 One especially advantageous door leaf construction embodying the invention, to be described in detail hereafter, uses fibre-reinforced cement panels each of which has an outer skin of higher density than the rest of the panel. Such panels are currently available  
25 commercially, and lend themselves ideally to the construction of a door leaf embodying the invention. The outer skin protects the rest of the panel from impact, and door furniture such as locks, latches and bolts can be screwed direct to it without necessarily having to  
30 be screwed through to the core membrane.

If a capping channel extends around the periphery of the door leaf, it may advantageously be made of material which is compatible with the core membrane so that it can be heat-welded through to the core membrane. This  
35 will increase the flexural rigidity of the door still farther, will protect the panel edges, and can do away

with any need to bond the panels to the membrane itself.

5 The membrane may be of tray form, with tray walls formed around any two opposite edges or around all four edges of the membrane. This could provide the advantageous air gap between the heat-resistant panels of the door leaf without necessarily having to corrugate the membrane. It could also have a capping channel heat-welded to it around the entire periphery of the leaf, in the case where a four-wall tray was used, 10 whereas an unwallled corrugated membrane could normally only be welded to the capping channel along two of the membrane's opposite edges.

15 Where a corrugated membrane is used, the corrugations are advantageously straight-walled rather than curve-walled in form, and the acute angle between the wall and the base is preferably within the range 30 degrees to 90 degrees. Angles outside the limits of this range will be less resistant to buckling.

20 In the case just outlined, an especially advantageous range of angle is between 45 degrees and 90 degrees to give optimum strength to the corrugated membrane.

25 Where a corrugated membrane is used, the corrugations preferably run across the door leaf, i.e. from side to side rather than from top to bottom, since the leaf is then flexurally more rigid in the directions in which it is most likely to be subject to bending forces in use.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

30 Figure 1 shows a door leaf embodying the invention, in plan cross-section;

Figure 2 shows the door leaf of Figure 1 in front elevation when installed in its surrounding door frame;

Figures 3 and 4 show respectively the hinge-end and latch-end of the door leaf in plan cross-section, and also show part of the door frame in each case;

5        Figures 5A to 5E are diagrammatic illustrations of different forms which the core membrane of the door leaf might take within the scope of the invention; and

Figures 6 to 12 are similarly diagrammatic illustrations of ways in which the door leaf might be modified within the scope of the invention.

10       Figures 3 and 4 are drawn to a larger scale than Figures 1 and 2, and they are each sections along the line B-B of Figure 2.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

15       The door assembly illustrated, and its possible modifications, will now be described with reference to the drawing. The door leaf itself is only one of several forms which the invention might take. It is, however, the best form currently known to the applicant of putting the invention into practice.

20       The door leaf comprises a corrugated mild steel folded plate sandwiched between two fibre-reinforced cement panels and bounded by a stainless steel peripheral capping channel. The steel membrane, referenced 11, has corrugations extending across the width of the  
25       door leaf. The corrugations are straight-walled, and the reflex angle between the wall and base of each corrugation is 135 degrees; so that the acute angle defined between each wall and base is 45 degrees in this particular embodiment.

30       The fibre-reinforced cement panels each have the same reference 12 and are each glued to respective channel base portions of the corrugated steel plate membrane 11. Each panel 12 is of uniform density for the greater part of its thickness, but each exhibits a hard skin region

of much higher density on its outward-facing surface.  
The skin region is referenced 12a in each case.

The capping channel 13 is U-shaped in cross-section.  
It extends around the periphery of the composite rectangular panel-core membrane-panel "sandwich", and it is  
5 corner-mitred and welded into a rectangular framework.  
It is made, in this particular embodiment, of stainless steel.

The opposite top and bottom edges of the core membrane  
10 11 are turned over at 90 degrees to the general plane  
of the membrane, so that they constitute flanges  
abutting the adjacent inner face of the capping channel  
13. Holes are formed in the channel 13 at points  
15 spaced along its length where it abuts the membrane-  
edge flanges just referred to. The membrane-edges  
are then spot-welded to the capping channel 13 through  
these holes, and the welds later ground flat against  
the outer face of the channel.

Because the core membrane 11 is corrugated, an air gap  
20 14 is created between the two fibre-reinforced cement  
panels 12. In the particular embodiment illustrated,  
there is a 20 mm spacing between the non-skinned facing  
inner surfaces of the two panels 12. The core mem-  
brane is folded from mild steel plate 1.6 mm thick.  
25 Each of the panels has an overall thickness of 15 mm  
and the hard outer-facing skin of each panel is 2 mm  
thick. The door leaf overall is 2440 mm high x  
1200 mm wide.

The construction of the door frame surrounding the leaf  
30 is not of the essence of the invention, and can readily  
be settled by those skilled in this field. Essentially,  
however, as shown in Figures 3 and 4 the frame uprights  
15 are steel Z-rails which are bolted direct to the  
steel bulkhead 16 in which the door opening is formed.

35 The latch and hinge construction is similarly not of



the essence of the invention, and can readily be settled by the skilled reader, but it is clear from Figure 3 that one of the hinge plates 17 is welded to a reinforcing plate 18 on the door leaf whilst the other hinge plate, not shown, is welded to the door frame up-right 15; and the reinforcing plate 18 is L-shaped and is welded inside the capping channel 13 and to the core membrane 11 at each of the three hinge points along the relevant edge of the door leaf.

5  
10 A U-shaped spine 19 sits in the air gap between the two heat-resistant panels 12 and is welded to the membrane 11 along the length of the spine. The spine 19 extends almost the full length of the door leaf.

15 The fibre-reinforced panels illustrated and referenced 12 have an average density of 1.1 tonnes per cubic metre to within plus or minus 15 per cent. The greater thickness of the panel has a density of 0.8 tonnes per cubic metre, whilst the 2 mm-thick skins have densities of 1.6 tonnes per cubic metre, again all to within plus or minus 15 per cent. These panels are pre-manufactured as rigid skinned boards and are currently available under the trade mark VELMAC in the United Kingdom from Tarmac Industrial Holdings Limited, of Ettingshall, Wolverhampton, United Kingdom. They are glued to the core membrane by an adhesive manufactured in the United Kingdom by Joseph Crossfield and Sons Limited, of Warrington, Cheshire, United Kingdom and known as Claysil No 1 Adhesive. The panels 12 are relatively light in weight but their hard outer skins have high impact resistance and are hard enough for door furniture to be screwed direct to them. They are waterproof and rot-proof, they cut down noise transmission, and they are self-coloured although they can be painted if desired.

30  
35 The door leaf illustrated passes an A60 standard fire test and is some 20 per cent lighter in weight than a

similarly-sized and similarly-rated A60 door of conventional steel outer panel - heat-resistant core construction.

5 Instead of using pre-manufactured boards for the panels  
12, the fibre-reinforced cement could be sprayed onto  
each side of the corrugated core membrane 11 and then  
left to set into a rigid panel. The air gap 14 would  
then not be present, but if the material were sprayed  
thick enough the necessary fire-resistant qualities  
10 could still be achieved. One form of fibre-reinforced  
cement (or GRC as it is usually called) which could be  
sprayed in this manner is currently marketed in the  
United Kingdom by Thyssen (Great Britain) Limited of  
Bynea, Llanelli, Dyfed, United Kingdom.

15 The three hinges which hang the door on its frame could  
consist of two plain hinges and one self-closing hinge.  
One of these hinges could be replaced by a dog bolt and  
still conform to Regulations. There are three latches  
spaced along the non-hinged edge of the door, each  
20 latch opposite a respective hinge.

Figures 5A to 5E show diagrammatically various forms  
the corrugated core membrane 11 might take. In Figure  
5A the corrugations are straight-walled and are  
regularly spaced from one another. In Figure 5B they  
25 are relatively widely spaced. In each of these two  
cases the corrugations are angular in form.

Instead of being angular in form, successive corrugations may be right-angled and again may be regularly spaced (Figure 5C) or relatively widely spaced (Figure  
30 5D) to define in either case a series of "top hat"  
sections along or across the membrane 11.

It is even conceivable that a curved corrugated  
regularly-spaced or irregularly-spaced form (Figure 5E)  
could be used. To give such a form sufficient rigidity,  
35 the membrane may have to be made of steel, but in

any door leaf embodying the invention the materials will be chosen according to the degree of fire resistance required.

5       The tray-form membrane of Figure 6 has upturned walls along its two opposite longitudinal edges, and "top hat" reinforcing channels running across it at each of three spaced positions where the hinges will be installed down one door edge. Figure 7 shows a similar arrangement in which the stiffening reinforcing  
10       sections are localised around the three hinge regions, and around a single latch region on the opposite edge of the membrane, and in which the membrane this time has walls along each of its four edges.

15       Figure 8 is a section through one of the reinforced hinge regions of the completed door leaf using the Figure 7 membrane. The localised reinforcing sections are each screwed through the floor of the tray-form membrane to one of the outer heat-resisting panels. The non-screwed end of the reinforcing section may be  
20       welded, glued, riveted or otherwise secured to the upturned wall of the tray-form membrane. Alternatively, as shown in Figure 8, it could simply be left to bear unsecured against the underside of the inturned wall of the membrane if the membrane and reinforcing section  
25       were each sufficiently rigid.

      Instead of using a capping channel such as 13 illustrated in Figures 3 and 4, two tray-form membranes could be secured back to back. Each could be folded up around an outer panel of heat-resistant material,  
30       and when two such membrane-and-panel assemblies were secured back to back, the door leaf assembly of membrane and outer panels would be completed. If the heat-resistant panels were in the form of pre-manufactured rigid boards, they could be left unglued  
35       within the membranes, and be kept in place by the folded-over tray walls.

In the arrangement just outlined, a capping channel could still be fitted around the four edges of the assembled back to back panels and membranes if desired.

5 Figure 9 shows a door leaf assembly in which the heat-resistant outer panels are rigid boards and are separated by individual core membrane elements glued and/or screwed into position on the inward-facing surfaces of the panels. A capping channel of stainless steel is glued and/or screwed to the boards or is alternatively  
10 welded up around the boards as a framework without being secured to them. The core region contains an air gap as well as containing individual core elements, and the individual elements together constitute the required leaf-stiffening membrane.

15 In arrangements where a capping channel is used, Figures 10, 11 and 12 illustrate various ways in which the channel may be secured in position. In Figure 10 the channel is through-welded to the walls of a tray-form membrane. In Figure 11 the walls of the channel  
20 are screwed to the heat-resistant boards which are themselves separated by a continuous corrugated membrane or a series of individual core elements which together constitute a membrane. In each of these two cases there is an air gap between the outer panels and  
25 the air gap forms part of the core region.

o In Figure 12 there is no air gap. The core region consists solely of a relatively stiff membrane faced on each of its opposite sides with heat-resistant material and with a capping channel welded up around the four  
30 edges of the resulting door leaf assembly. The capping channel is not secured to the membrane, nor is it secured to the heat-resistant outer panels. Its corners are mitred and welded to hold the panels and the membrane in place inside it.

CLAIMS

1. A fire-resistant door leaf suitable for closing-off an opening in a marine bulkhead, the door leaf comprising a core sandwiched between two panels, and characterised in that the core region contains a membrane (11) of relatively high flexural rigidity and high thermal conductivity whilst the panels (12) each exhibit a thermal conductivity which is much lower than that of the core membrane (11) and are each much thicker than the core membrane (11).
2. A door leaf according to Claim 1 and characterised in that the core membrane (11) is corrugated.
3. A door leaf according to Claim 1 or Claim 2 and characterised in that there is an air gap (14) between the two outer panels (12) in the core region of the door leaf.
4. A door leaf according to any of the preceding Claims and characterised in that the panels (12) are each composed of fibre-reinforced cement material exhibiting an outward-facing skin (12a) of higher density than the rest of the panel.
5. A door leaf according to any of the preceding Claims and characterised in that a capping channel (13) extends around the periphery of the door leaf, in that the channel (13) is made of material which is heat-weldable to the core membrane (11), and in that the channel (13) is heat-welded through to the core membrane (11).
6. A door leaf according to any of the preceding Claims and characterised in that the core membrane (11) is a tray-form membrane with upturned walls along opposite edges of the tray.
7. A door leaf according to any of Claims 2 to 6 and characterised in that the corrugations are straight-

walled and in that the walls of the corrugations are angled between 90 degrees and 150 degrees to the base of the corrugations.

5 8. A door leaf according to Claim 7 and characterised in that the said angle is within the range 90 degrees to 135 degrees.

9. A door leaf according to any of Claims 2 to 8 and characterised in that the corrugations run across the width of the door leaf.

10 10. A door leaf suitable for use in closing-off an opening in a marine bulkhead, characterised in that the door leaf comprises a corrugated steel membrane (11) sandwiched between two fibre-reinforced cement panel boards (12) with an air gap (14) created between  
15 the panels (12) by the corrugated membrane (11) and with each panel (12) being of substantially identical thickness and spaced apart by at least a panel thickness by the air gap (14) and with each panel having on  
20 its outward-facing surface a skin whose density is approximately twice that of the rest of the panel.

FIG. 1.

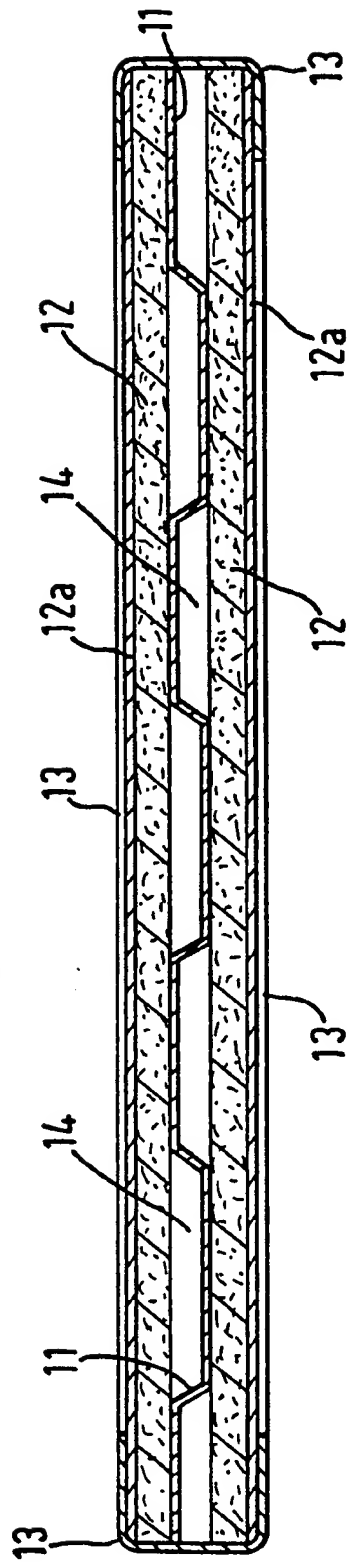


FIG. 3.

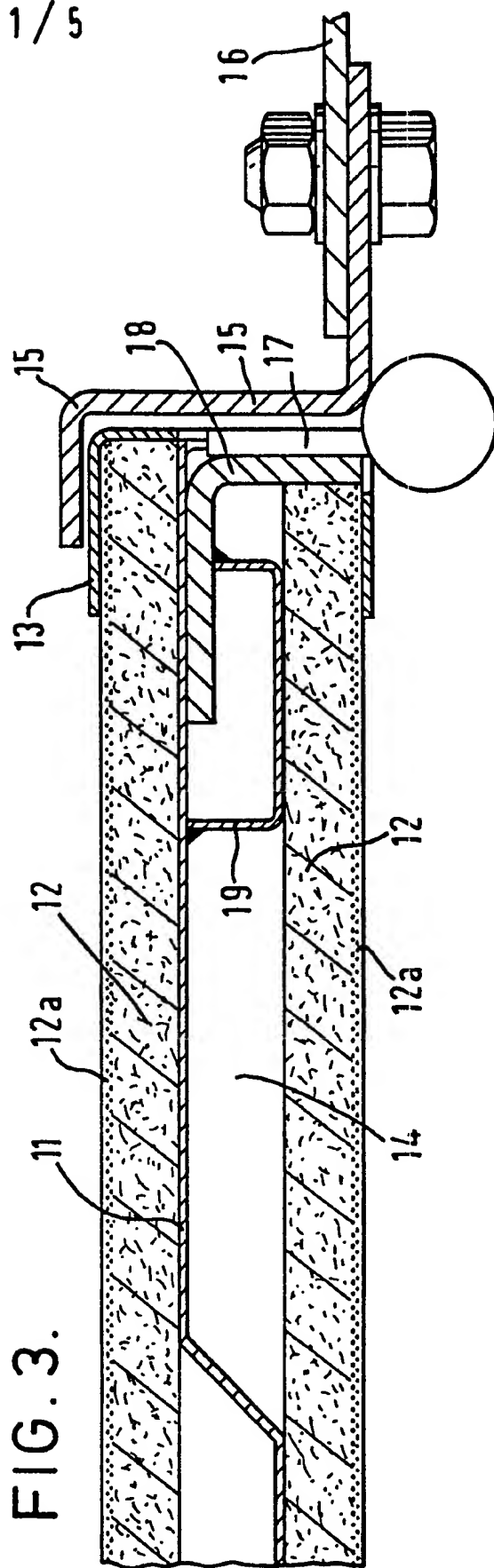
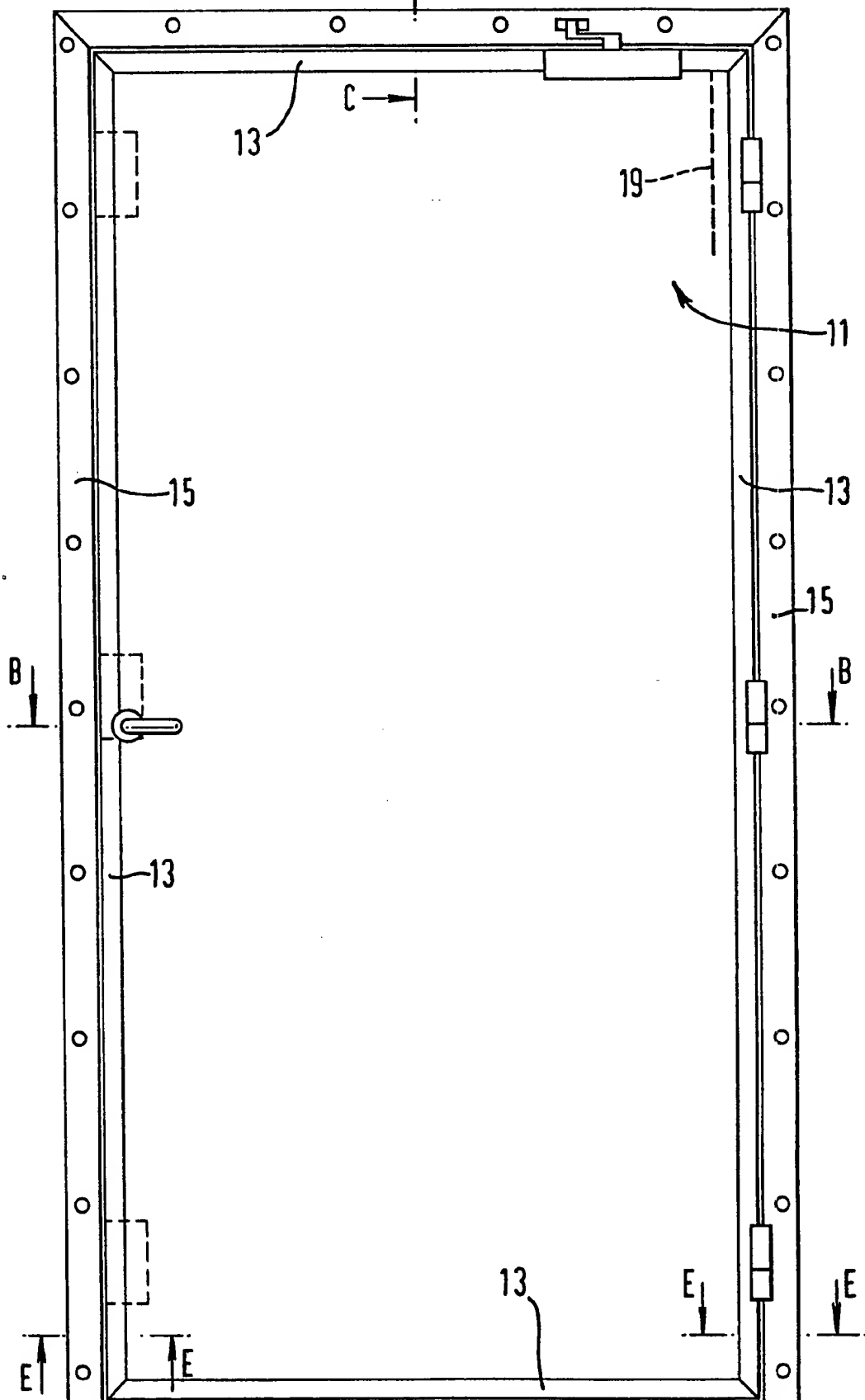


FIG. 2.

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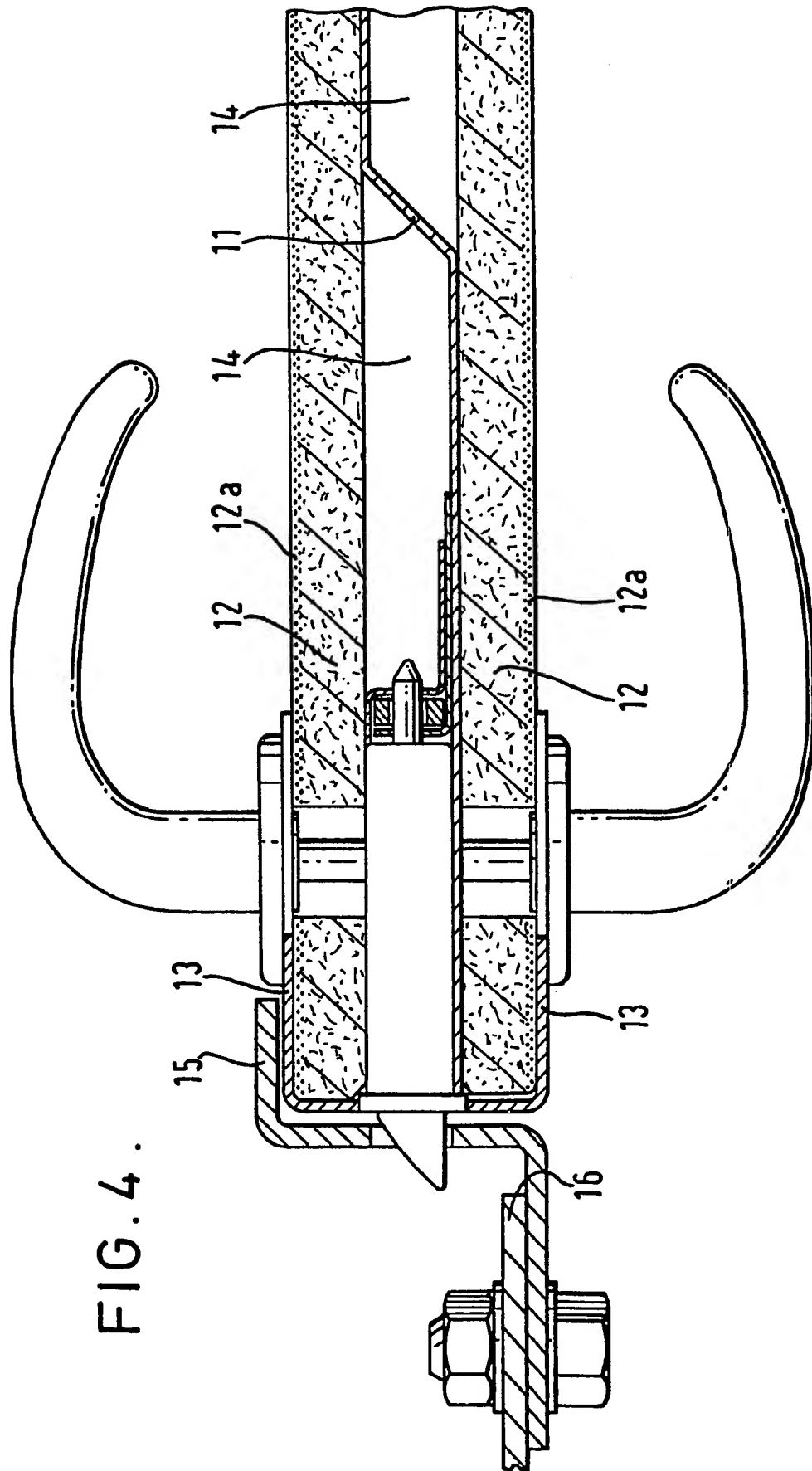


FIG. 4.

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FIG. 5A.



FIG. 5B.



FIG. 5C.



FIG. 5D.



FIG. 5E.

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FIG. 6.

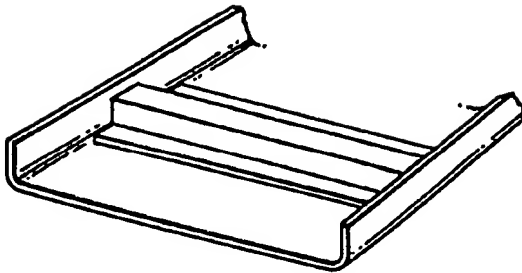


FIG. 7.

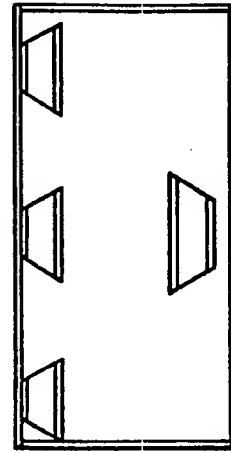


FIG. 8.

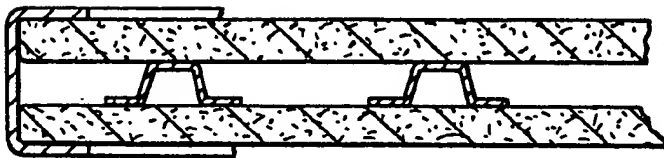
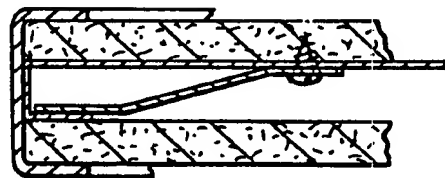


FIG. 9.

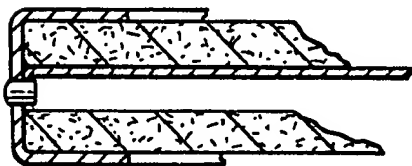


FIG. 10.

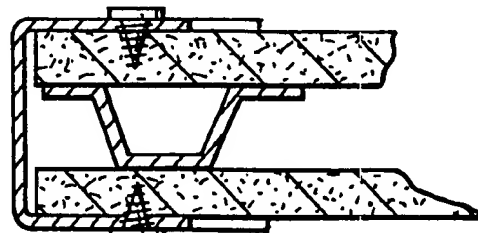


FIG. 11.



FIG. 12.



European Patent  
Office

# EUROPEAN SEARCH REPORT

0076025

Application number

EP 82 30 3922

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 2)
X	GB-A- 14 114 (WHEELER)(AD1913) * Page 1, lines 28-45; page 2, lines 1-9, 37-57; figures 1-6 *	1-3, 7, 10	E 06 B 5/16 B 63 B 19/00
X	FR-A-2 380 407 (JUNGBLUTH) * Page 1, lines 1-38; figure 1 *	1, 2, 4, 7, 10	
X	GB-A- 9 822 (LIEBERT)(AD1911) * Page 2, lines 13-25; page 3, lines 20-25; figures 1, 2 *	1-3, 7, 10	
X	GB-A- 23 022 (FIREPROOF DOORS)(AD1909) * Page 1, lines 14-31; figures 1-6 *	1-3, 5, 7-10	
X	BE-A- 830 581 (SCHWARZE) * Page 3, paragraph 5; page 4, paragraphs 1, 3; page 5, paragraph 1; figures 1-3 *	1-3, 5, 7, 8, 10	E 06 B B 63 B
X	US-A-2 196 781 (SAINO) * Page 2, column 1, lines 46-71; column 2, lines 31-52; page 5, column 2, lines 56-75; page 6, column 1, lines 1, 2; figures 1-3 *	1-3, 10	
-/-			
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		18-10-1982	DEPOORTER F.
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	



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# EUROPEAN SEARCH REPORT

0076025  
Application number

EP 82 30 3922

DOCUMENTS CONSIDERED TO BE RELEVANT			Page 2
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	GB-A- 728 984 (MANNESMANN) * Page 2, lines 62-74; claims 1,7,8; figure 5 *  -----	1,4-6	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 18-10-1982	Examiner DEPOORTER F.
<b>CATEGORY OF CITED DOCUMENTS</b>			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons  & : member of the same patent family, corresponding document	